Easy Medical Device

HOW TO SET UP A CLEANROOM FOR YOUR MEDICAL DEVICE INDUSTRY?

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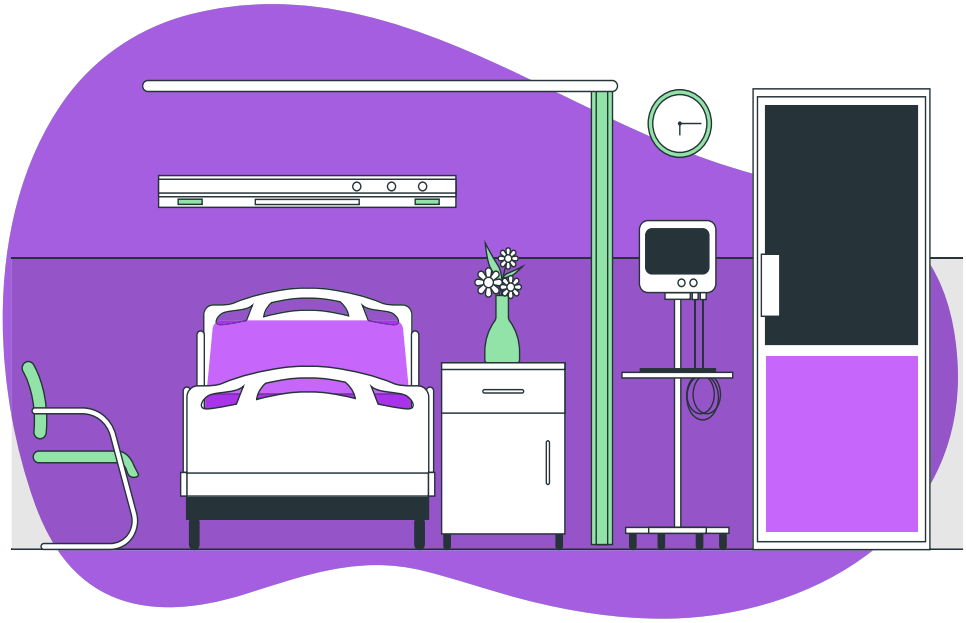
For some manufacturers, a cleanroom is maybe too much; for others, it is crucial. I will try to explain to you the most important criteria to consider if you want to set up your cleanroom.

Manufacturing environment conditions are essential for producing safe pharmaceuticals, medical devices, and biotherapeutics. Unwanted cross-contamination can be reduced by regulating and overseeing the manufacturing environment, which also helps to guarantee products with a high level of sterility assurance.

Below you can look at a podcast episode where I interviewed Philippe Bourbon from Groupe Icare Laboratory. You will get a great insight into our discussion by checking this video.



What is a cleanroom ?

A clean room is not just a white room with four walls and a few pieces of equipment. It is a sterile setting created to get rid of airborne contaminants like dust, germs, aerosol particles, and pollutants to produce a clean and controlled environment for a variety of purposes from the manufacturing of medical devices and pharmaceuticals to scientific research.

Manufacturing and packaging of medical equipment require a controlled environment and these cleanrooms must abide by some strict regulations.

The majority of medical device cleanrooms are required to follow ISO 14644 guidelines2, which place limits on the amount of permissible particulate matter in the controlled environment.

In this article, we'll go over the basics of a clean room and the primary conditions necessary for clean room validation, taking into account the following standards:

- **ISO 14644-1:2015** – classification of Cleanrooms based on air cleanliness by particle concentration
- **ISO 14644-2:2015** – Cleanroom Classification Monitoring
- **ISO 14644-3:2019** – Test methods for cleanrooms
- **European GMP guidelines** provide a system of processes, procedures, and documentation to ensure that a product is consistently produced and controlled according to quality standards. GMP guidelines are often used in the pharmaceutical and food industries to set up and operate cleanrooms.
- **Federal Standard 209E:** This standard was developed by the U.S. General Services Administration (GSA) and is used to classify cleanrooms based on the concentration of airborne particles. [CANCELLED]
- **USP <797>:** This standard was developed by the United States Pharmacopeia (USP) and is used to establish the requirements for cleanrooms in the pharmaceutical industry.

Steps to follow

To set up a clean room for the medical device industry, you will need to follow these steps.

1-Determine the cleanliness level required: The level of cleanliness required for a clean room will depend on the specific requirements of the products being manufactured or assembled. For example, a Class 10,000 clean room (also known as an ISO 7 clean room) is typically sufficient for most medical device manufacturing, while a Class 100,000 clean room (also known as an ISO 8 clean room) may be required for lower-risk products.

2-Select an appropriate location : Choose a location for the clean room that is away from sources of contamination, such as windows, doors, and HVAC systems. The location should also have sufficient space and power to accommodate the equipment and personnel required for the clean room.

3-Install an air filtration system : A clean room must have a controlled air supply that is filtered to remove contaminants. Install an air filtration system that is appropriate for the cleanliness level required.

4-Set up a control area : Establish a control area outside of the clean room where personnel can gown up and prepare for entry into the clean room. This area should be equipped with lockers for storing personal items, as well as hand-washing and sanitizing stations.

5-Establish protocols for personnel and equipment : Develop protocols for personnel and equipment entering and exiting the clean room, including gowning and decontamination procedures. Establish procedures for cleaning and maintaining the clean room to ensure that it

How clean is clean?

Clean rooms are classified according to the cleanliness level of the air inside the controlled environment i.e the quantity and size of particles per cubic meter of air.

The ISO 14644-1 classification system has nine classes, numbered from 1 to 9, with Class 1 indicating the cleanest cleanroom environment and Class 9 indicating room air.

Cleanrooms are subjected to stricter regulations as the classification number decreases. The majority of cleanrooms fall under ISO Classes 7-8 with ISO 5 being a transition level where strict criteria for filtration, contamination, and environmental control are applied.

Class	Maximum Allowed Particles (per m3)					Air Change Rate (per hour)	Airflow Velocity (ft/min)	Ceiling Coverage	FEDERAL 209E STANDARD
	>0.2 um	>0.3 um	>0.5 um	>1 um	>5 um				
ISO 1	2.37	1.02	0.35	0.083	0.0029	360-600	60-100	90-100%	N/A
ISO 2	23.7	10.2	3.5	0.83	0.029	360-600	60-100	80-100%	N/A
ISO 3	237	102	35	8.3	0.29	360-540	60-90	60-100%	CLASS 1
ISO 4	2,370	1,020	352	83	2.9	300-540	50-90	50-90%	CLASS 10
ISO 5	23,700	10,200	3,520	832	29	240-480	40-80	35-70%	CLASS 100
ISO 6	237,000	102,000	35,200	8,320	293	150-240	25-40	25-40%	CLASS 1000
ISO 7	2.37x106	1,020,000	352,000	83,200	2,930	60-90	10-15	15-20%	CLASS 10,000
ISO 8	2.37x107	1.02x107	3,520,000	832,000	29,300	5-48	1-8	5-15%	CLASS 100,000
ISO 9	2.37x108	1.02x108	35,200,000	8,320,000	293,000	0-25	0-5	5-10%	Room Air

What is a cleanroom «at rest» vs. «in operation» ?

It's crucial to keep in mind that cleanrooms with an ISO Class 5 or lower evaluate cleanliness at several phases, primarily "in operation" and "at rest."

A cleanroom that is "at rest" indicates that it has all of its furnishings, equipment, and other components but is empty of any workers or operational activities.

On the other hand, "in operation" implies that all personnel and equipment are operating at peak efficiency. Since there is less activity in the room and fewer pollutants are being shed or transferred, achieving certification "at rest" requires less filtration and precautions.

Let's look now at this video on "A day in the life of a Clean Room Technician."

How to design and validate the cleanliness of a Cleanroom?

ISO 14644-2 describes the practices for testing and monitoring cleanrooms to ensure they comply with classification standards. All cleanrooms require periodic testing to make sure they reach the necessary particle count allowances and are effectively maintaining a clean environment. The major components of cleanroom design include cleanroom filtration, airflow patterns, pressurization, HVAC systems, and other cleanroom supplies and materials.

Cleanroom filtration

They are required to filter out a certain number of particles of a specific size, depending on your cleanroom classification. To provide consistent and contaminant-free air, particles are removed using High-efficiency particulate air (HEPA) or ultra-low particulate air (ULPA) filters, according to the target particle size.

HEPA filters effectively remove 99.97% of airborne particles, down to a size of 0.3 microns (0.0003 mm). ULPA filters, on the other hand, are even more effective, eliminating at least 99.999% of dust, pollen, mold, germs, and other airborne particles as small as 100 nanometres (0.0001mm).

Regular particle count checks should be undertaken to confirm that the particle count is within the cleanroom's specified range.

Airflow patterns

Airflow patterns are critical as you design your cleanroom. Air should flow without leaving any gaps where pollutants can accumulate and obstruct filters in a unidirectional air or non-unidirectional flow depending on the manufacturing requirements.

Airflow should be validated according to various parameters like velocity, volumetric flow, directional flow, and reflux.

Pressurization

The amount and direction of air flowing in and out of the cleanroom environment determine pressure within the cleanroom. Positive pressure is used in most cleanrooms, which means that more air is filtered into the chamber than removed. Positive pressure keeps air from seeping around doors, seams, or fissures and into the clean room, where it could cause contamination.

Any leaks in the cleanroom can increase the number of undesirable particles entering the cleanroom and reduce its cleanliness. Hence, Room Pressurization Measurement should be done to ensure that the specified room pressurization is met in order to avoid cross-contamination from a cleanroom with a lower cleanliness class into an area with a higher cleanliness class.

HVAC system

The HVAC system is an extremely important part of maintaining the cleanroom specification. It controls the temperature, humidity, and circulation of air within the cleanroom.

The HVAC system generates an environment that is not only comfortable for personnel to work in, but also safe from the risks of moisture, humidity, and temperature variations in order to maintain a stable environment for all products and operations.

The materials and furniture themselves must also be cleanroom safe, as specified by your cleanroom classification. Some situations, for example, necessitate the use of ESD-safe (electro-static discharge) materials to protect employees and equipment against contamination or charges caused by static electricity.

What are the Best Practices Before entering a Cleanroom?

Contamination in cleanrooms can be reduced by ensuring that the employees wear gowns, hairnets, and overshoes. Maintaining a cleanroom schedule can help to ensure that all of these required criteria

are met. Regular risk assessments should be done to ensure that the changes made on an ongoing basis are addressed and tests are done to validate them. Here are some of the best practices to be followed to maintain the protocols for entering a cleanroom:

1. A cleanroom should have a hallway that is at least as clean as the room itself
2. The workers should maintain a good personal hygiene
3. The personal locker outside the gowning room should be used to store all personal items, including cigarettes, keys, watches, rings, jewelry, and makeup.
4. Put a sticky mat and a trash can at the entrance to dispose of any unnecessary items.
5. Don't smoke 30 minutes before entering.
6. Gowning Protocol should be thoroughly followed.
7. Always use the proper designated entrances to enter and exit.
8. Use your back to open the door or rather than gloved hands. Also, use the back of your hands to adjust glasses if necessary
9. Before getting any new materials into the cleanroom, use air showers and pass-throughs to sanitize. Conduct all cleanroom maintenance in isolation.

Here are some instructions that you can have within your cleanroom.

Cleanroom Apparel Guide (Non-Sterile)

BLUE THUNDER TECHNOLOGIES

Before Entering

1. Bouffant Cap

Use a bouffant cap to completely cover hair.

2. Shoe Covers

Place shoe cover over the entire shoe and contain laces.

3. Cleanroom Gloves

Some cleanrooms require that you use gloves while dressing. This will be the first of two sets.

4. Mask

Bend nosepiece so mask fits on face.

5. Hood

Put hood over mask and ensure face/neck seal are not exposed.

6. Coverall

Step into coverall, making sure sleeves and upper garment do not touch any objects outside of cleanroom.

Tuck hood panels inside coverall before zipping up.

7. Boot Covers

Place boot covers over legs of coveralls.

8. Eye Protection

Put on goggles if your cleanroom requires eye protection.

9. Cleanroom Gloves

Put on over first set of gloves or remove first set and then put on cleanroom gloves. Make sure gloves cover cover of sleeve.

Cleanroom Tack Mat

It is very important to prevent contamination and maintain cleanliness by using sticky cleanroom mats before entering the cleanroom area.

Walk on the mat and roll any carts entering the cleanroom over the mat.

Apparel Removal Guide

1. Gloves

2. Eye Protection

3. Boot Covers

4. Coverall

5. Hood

6. Bouffant Cap

7. Shoe Covers

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The above diagram is a recommendation only. Not all cleanrooms will use the same gowning procedures. Follow your specific cleanroom or company procedural manual before this guide.

Can an auditor challenge the Cleanroom Specifications?

The answer to this question is an absolute “yes” and in fact, he should challenge the manufacturer so that the adequacy of the cleanroom is proven. The manufacturer has to be thoroughly prepared with validation reports and evidence backing up his decision to select a particular ISO level of the cleanroom.

Production, assembly, and packaging of medical devices all have various standards for cleanliness and have different cleanroom classifications. According to ISO 14644-1, the majority of medical device manufacturing cleanrooms must adhere to ISO 5-8 requirements, while medical device packaging needs ISO 7-8.

Additionally, all cleanrooms for medical devices must adhere to ISO 13485:2016, which specifies a quality management system to guarantee product quality and assures benefits over risks of the device.

Who can help you design your Cleanroom?

You might be a little overwhelmed after reading about all of the elements that go into cleanroom design.

This is where a cleanroom company may help. Having a team member who is familiar with all the many parts of a cleanroom and can assist you design one that meets your classification standard, your space, and your budget is beneficial when planning the design and installation project.

Few websites and companies that are Cleanroom providers:

- Medical device network
- Medical Device directory
- Terra Universal
- Angstrom Technologies
- Mecart Cleanrooms
- Total environment looking
- Starfish Medical
- Cleanroom Australia
- Panel Built, Inc.
- Abtech, Inc.
- Clean Rooms International, Inc.

What Is The Estimated Cost Of Building A Cleanroom?

The cost typically increases as your specifications get more stringent. For instance, a Class 10,000 cleanroom will be more expensive than a Class 100 cleanroom. Filtration, temperature, humidity control, and other costs may influence the overall budget.

According to Philip, a new cleanroom may cost approximately 1000 to 10,000 euros per square meter depending on the ISO level. To give an example, shorter ceilings may result in larger rooms, which means you’ll need to pump in more air to make sure you’re meeting your cleanroom’s criteria for the required air exchange rate.

Additionally, the more air you need to pump in, the more it will cost to operate.

To sum it up, cleanrooms are an essential aspect of the manufacturing process industries where product quality is easily influenced by external factors such as temperature, contaminants, and air pressure. Validation testing of a cleanroom prior to usage assures that production output is predictable and that product requirement are

How to monitor a cleanroom ?

There are several ways to monitor a cleanroom to ensure that it meets the required cleanliness standards:

- **Airmonitoring:** Airmonitoringinvolvesmeasuring the concentration of contaminants in the air. This can be done using air samplers, which collect samples of the air and analyze them for the presence of contaminants.
- **Particle counting:** Particle counting involves measuring the number and size of particles in the air. This can be done using a particle counter, which is a device that measures the number and size of particles in the air.
- **Surfacemonitoring:** Surfacemonitoringinvolves measuring the level of contamination on surfaces within the cleanroom. This can be done using swabs or contact plates, which are placed on surfaces and then analyzed for the presence of contaminants.
- **Personnel monitoring:** Personnel monitoring involves measuring the level of contamination on the clothing and skin of personnel working in the cleanroom. This can be done using skin or clothing samplers, which are placed on the skin or clothing and then analyzed for the presence of contaminants.
- **Environmental monitoring:** Environmental monitoring involves measuring the temperature, humidity, and pressure within the cleanroom. This can be done using sensors or monitoring devices that are placed within the cleanroom.

It is important to regularly monitor a cleanroom to ensure that it is operating at the required level of cleanliness and to identify any potential contamination issues.

Who can help you monitoring your Cleanroom?

Cleanrooms are typically monitored by trained personnel who are responsible for ensuring that the cleanroom meets the required level of cleanliness and contamination control. These personnel may include cleanroom operators, technicians, or quality control staff.

Cleanroom operators are responsible for maintaining the cleanroom environment and ensuring that it meets the required standards. This may involve monitoring the air quality, particle counts

When your cleanroom is installed, you can start to use it. But you should not forget to also have a maintenance plan in place and a re-validation process in case some elements change. Here are some companies that can help you:

- Groupe Icare
- Rotronic
- QA Consulting
- Sonicu
- Steris
- Pacific Biolabs

Let's Work Together

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